

CLAIMS

1. A non-aqueous secondary battery which employs a negative electrode in which the negative electrode active material is a material capable of lithium  
5 doping/dedoping, a positive electrode in which the positive electrode active material is a lithium-containing transition metal oxide, and a non-aqueous electrolyte solution as the electrolyte solution, wherein  
10 (1) the separator is composed of a porous film made of a porous polymer, which includes a network-like support, and swells in the electrolyte solution and retains said electrolyte solution,  
(2) said network-like support has a mean film thickness of 10-30  $\mu\text{m}$ , a basis weight of 6-20  $\text{g}/\text{m}^2$ , a  
15 Gurley value (JIS P8117) of no greater than 10 sec/100 cc, a McMullin number of no greater than 10 at 25°C and a (McMullin number x film thickness) product of no greater than 200  $\mu\text{m}$ .  
(3) said separator has a mean film thickness of 10-  
20 35  $\mu\text{m}$ , a basis weight of 10-25  $\text{g}/\text{m}^2$  and a Gurley value (JIS P8117) of no greater than 60 sec/100 cc, and  
(4) the following relationship:  
$$Q_{pr}W_p < q_m + Q_nW_n < 1.3Q_pW_p \quad I$$
  
is satisfied, wherein the value of the total amount of  
25 lithium in the positive electrode active material in terms of electric charge is  $Q_p$  (mAh/mg), the amount of lithium utilized for charge-discharge reaction of the lithium in the positive electrode active material in terms of electric charge is  $Q_{pr}$  (mAh/mg), the value of  
30 the amount of lithium which can be doped in the negative electrode active material in terms of electric charge is  $Q_n$  (mAh/mg), the value for the overcharge-preventing function of the separator is  $q_m$  (mAh/ $\text{cm}^2$ ), the weight of the positive electrode active material is  $W_p$  (mg/ $\text{cm}^2$ ) and  
35 the weight of the negative electrode active material is  $W_n$  (mg/ $\text{cm}^2$ ).

2. A battery according to claim 1, wherein  $Q_{prWp}/Q_{nWn} = 0.7-1.05$ .

3. A battery according to claim 1, wherein said positive electrode active material is a lithium-  
5 containing transition metal oxide represented by  $LiMO_2$ , where M is at least one metal element selected from the group consisting of cobalt, nickel, manganese, aluminum, iron, titanium and vanadium, and at least 1/3 of the atomic ratio composition of M is cobalt or nickel.

10 4. A battery according to claim 1, wherein said positive electrode active material is a lithium-containing transition metal oxide represented by  $LiM_2O_4$  where M is at least one metal element selected from the group consisting of manganese, magnesium, nickel, cobalt,  
15 chromium, copper, iron and boron, and at least 1/3 of the atomic ratio composition of M is manganese.

5. A battery according to claim 1, wherein said positive electrode active material is lithium nickelate ( $LiNiO_2$ ).

20 6. A battery according to claim 1, wherein said positive electrode active material is lithium manganate ( $LiMn_2O_4$ ).

7. A battery according to claim 1, wherein said positive electrode active material is composed of lithium  
25 manganate ( $LiMn_2O_4$ ) and lithium nickelate ( $LiNiO_2$ ).

8. A battery according to claim 1, wherein said network-like support is a nonwoven fabric.

9. A battery according to claim 8, wherein the fiber composing said nonwoven fabric is composed of at  
30 least one type of high-molecular-weight polymer selected from the group consisting of polyolefins, polyphenylene sulfide, aromatic polyamides and polyesters.

10. A battery according to claim 1, wherein said network-like support is a cloth.

35 11. A battery according to claim 10, wherein said network-like support is a glass cloth.

12. A battery according to any one of claims 1 to

11, wherein the overcharge-preventing function value  $q_m$  of said separator is in the range of 0.1-1.5 mAh/cm<sup>2</sup>.

13. A battery according to claim 12, wherein the overcharge-preventing function value  $q_m$  of said separator is in the range of 0.1-1.0 mAh/cm<sup>2</sup>.

14. A non-aqueous secondary battery which employs a negative electrode in which the negative electrode active material is a material capable of lithium doping/dedoping, a positive electrode in which the positive electrode active material is a lithium-containing transition metal oxide, and a non-aqueous electrolyte solution as the electrolyte solution, wherein

(1) the separator is composed of a porous film made of a porous polymer, which includes a network-like support, swells in the electrolyte solution and retains said electrolyte solution,

(2) said network-like support has a mean film thickness of 10-30  $\mu\text{m}$ , a basis weight of 6-20 g/m<sup>2</sup>, a Gurley value (JIS P8117) of no greater than 10 sec/100 cc, a McMullin number of no greater than 10 at 25°C and a (McMullin number x mean film thickness) product of no greater than 200  $\mu\text{m}$ .

(3) said separator has a mean film thickness of 10-35  $\mu\text{m}$ , a basis weight of 10-25 g/m<sup>2</sup> and a Gurley value (JIS P8117) exceeding 60 sec/100 cc and no greater than 500 sec/100 cc, and

(4) the following relationship:

$$Q_{pr}W_p < q_m + Q_nW_n < 1.3Q_pW_p \quad I$$

is satisfied, wherein the value of the total amount of lithium in the positive electrode active material in terms of electric charge is  $Q_p$  (mAh/mg), the amount of lithium utilized for charge-discharge reaction of the lithium in the positive electrode active material in terms of electric charge is  $Q_{pr}$  (mAh/mg), the value of the amount of lithium which can be doped in the negative electrode active material in terms of electric charge is

Qn (mAh/mg), the value for the overcharge-preventing function of the separator is  $q_m$  (mAh/cm<sup>2</sup>), the weight of the positive electrode active material is  $W_p$  (mg/cm<sup>2</sup>) and the weight of the negative electrode active material is  $W_n$  (mg/cm<sup>2</sup>).

15 15. A battery according to claim 14, wherein  $Q_{pr}W_p/Q_nW_n = 1.05-4.0$ .

10 16. A battery according to claim 14, wherein said positive electrode active material is a lithium-containing transition metal oxide represented by  $LiMO_2$ , where M is at least one metal element selected from the group consisting of cobalt, nickel, manganese, aluminum, iron, titanium and vanadium, and at least 1/3 of the atomic ratio composition of M is cobalt or nickel.

15 17. A battery according to claim 14, wherein said positive electrode active material is a lithium-containing transition metal oxide represented by  $LiM_2O_4$  where M is at least one metal element selected from the group consisting of manganese, magnesium, nickel, cobalt, chromium, copper, iron and boron, and at least 1/3 of the atomic ratio composition of M is manganese.

18. A battery according to claim 14, wherein said positive electrode active material is lithium nickelate ( $LiNiO_2$ ).

25 19. A battery according to claim 14, wherein said positive electrode active material is lithium manganate ( $LiMn_2O_4$ ).

30 20. A battery according to claim 14, wherein said positive electrode active material is composed of lithium manganate ( $LiMn_2O_4$ ) and lithium nickelate ( $LiNiO_2$ ).

21. A battery according to claim 14, wherein said network-like support is a nonwoven fabric.

35 22. A battery according to claim 21, wherein the fiber composing said nonwoven fabric is composed of at least one type of high-molecular-weight polymer selected from the group consisting of polyolefins, polyphenylene sulfide, aromatic polyamides and polyesters.

23. A battery according to claim 14, wherein said network-like support is a cloth.

24. A battery according to claim 23, wherein said network-like support is a glass cloth.

5        25. A battery according to any one of 14. to 24, wherein the overcharge-preventing function value  $q_m$  of said separator is in the range of 1.0-5.0 mAh/cm<sup>2</sup>.

10       26. A battery according to claim 25, wherein the overcharge-preventing function value  $q_m$  of said separator is in the range of 1.5-3.0 mAh/cm<sup>2</sup>.

15       27. A battery separator composed of a porous film made of a polymer, which includes a network-like support, and swells in the electrolyte solution and retains said electrolyte solution, wherein said network-like support has a mean film thickness of 10-30  $\mu$ m, a basis weight of 6-20 g/m<sup>2</sup>, a Gurley value (JIS P8117) of no greater than 10 sec/100 cc, a McMullin number of no greater than 10 at 25°C and a (McMullin number x mean film thickness) product of no greater than 200  $\mu$ m, and said porous film has a  
20       mean film thickness of 10-35  $\mu$ m, a basis weight of 10-25 g/m<sup>2</sup> and a Gurley value (JIS P8117) exceeding 60 sec/100 cc and no greater than 500 sec/100 cc.

28. A separator according to claim 27, wherein said network-like support is a nonwoven fabric.

25       29. A separator according to claim 28, wherein the fiber composing said nonwoven fabric is composed of at least one type of high-molecular-weight polymer selected from the group consisting of polyolefins, polyphenylene sulfide, aromatic polyamides and polyesters.

30       30. A separator according to claim 27, wherein said network-like support is a cloth.

31. A separator according to claim 30, wherein said network-like support is a glass cloth.

35       32. A separator according to claim 27 above, wherein said organic polymer is polyvinylidene fluoride (PVdF), a PVdF copolymer or a compound composed mainly of

PVdF.